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Fanwort, Cabomba caroliniana(Gray) is frequently found in acid ponds, lakes and quiet streams with a pH between 4 and 6, in the southeastern United States. It is generally rooted in water to 3m deep, but may continue to grow after it has been uprooted from the substrate. It is a popular aquarium plant and has been widely scattered by discarded aquarium plantings. This native plant can clog drainage canals and fresh water streams and prevent general usage of the water for industrial and domestic purposes.

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THE ECOLOGY AND ENVIRONMENTAL IMPACT OF FANWORT[1]

by

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Washington, D.C.

ABSTRACT

Fanwort, Cabomba caroliniana (Gray) is frequently found in acid ponds, lakes and quiet streams with a pH between 4 and 6. It is generally rooted in water to 3m deep, but may continue to grow after is has been uprooted from the substrate. It is a popular aquarium plant and has been widely scattered by discarded aquarium plantings. This native plant can clog drainage canals and fresh water streams and prevent general usage of the water for industrial and domestic purposes.

INTRODUCTION

In the United States, cabomba is chiefly found along the coastal plain from Virginia to south Florida, and west to Texas and northward to Oklahoma, Illinois and Tennessee. Cabomba caroliniana (green-cabomba) and C. pulcherrima (purple-cabomba) are native throughout the

1 The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

southeastern United States. These submersed aquatic perennials are popular aquarium plants and their spread into other areas has been aided by the careless dumping of aquariums into natural water resources (1, 2, 3, 4, 5, 6, 7, 8).

No lake in northern Louisiana typifies the extent of the spread of Cabomba more than Black Lake in northern Natchitoches Parish. Approximately 2000 of its 6000 ha are now infested with Cabomba, whereas it was hardly found in the lake 10 years ago. This species has the ability to grow in shallow or deep water. The economic impact of the infestation by Cabomba has been evident. Several commercial fishing camps have closed, others have faced marked decrease in gross income, private camp owners have sold their lake property, and many hunters, boaters, and fishermen have taken their recreation dollars to other areas.

The first major change to occur in the ecology of Black Lake is that the stream flow pattern of Red River changed as a result of a series of flood control projects upstream. Prior to 1960, flood waters of the Red River entered the Black Lake system by backing-up over the gates at Allen Dam and also over the spillway at Chivary Dam. This periodic flooding helped control submergent aquatic plants in Black Lake in three ways. First, murky water entered the lake and sometimes persisted for as long as 1 to 2 months. This usually occured in the early spring at the time submergent plants would be initiating spring growth. The murky water reduced light penetration drastically and thereby prevented establishment in deeper areas. Secondly, the river water carried a heavy nutrient load. This probably resulted in an increased phytoplankton population, which in turn would result in a decrease in vascular plant populations due to the decrease in light penetration. Thirdly, the backwaters introduced new populations of buffalo, carp, and catfish into the lake. These species contributed to holding down aquatic plant populations by feeding directly on the submergent plants and by churning up the bottom, thereby increasing the turbidity of the water.

The second major change in the ecology of the area, which has led to conditions in Black Lake favorably for the growth of Cabomba, is a change in farming practices within the Black Lake Bayou watershed (the major stream feeding Black Lake). As late as the mid-1950s, much hill land in this watershed was actively farmed, being planted primarily in cotton and corn.

PROGRAM OF RESEARCH[1]

A series five experiments was conducted to determine conditions conducive to germination of Cabomba seeds. Seeds from several sites and collecting dates were collected by hand. Only swollen pistils beginning to darken were selected, and these were placed in jars containing lake water. Seeds were considered mature when they had fallen to the bottom of the jar and were a dark color. It was necessary to collect seeds prior to field ripening, because field-ripened seeds fall from the pedicel soon after maturity. This could have had an effect on the low germination rates observed in this study. Seeds were subjected to approximately 15 treatments, with each being replicated twice. About 25% of seeds involved in Experiment I germinated within 2 months. This proved that Cabomba is capable of sexual reproduction in Louisiana and that a period of after-ripening is not necessary for germination to occur. Riemer and Ilnicki (5) found no sexual reproduction in Cabomba from New Jersey, although seeds were produced there. Germination rates were very low (10%), except for seeds stored in a greenhouse (85%). Field studies indicate

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1 Abstracted from, The Ecology of Cabomba caroliniana by Dan R. Sanders, Sr., formerly Botanist, Northwestern State University of Louisiana, Natchitoches, Louisiana. Cooperative study with the New Orleans District, U.S. Army Corps of Engineers, and the Office of Chief of Engineers, Washington, D.C., with permission.

that Cabomba seeds remain viable for more than 2 years after production. A study in which pl)ts were established in September 1973 in Black Lake revealed seedling production in May 1974.

Water Level Manipulation

Five seedlings were planted in 2.5 cm of hydrosoil in each of four aquaria filled with water from Black Lake and were allowed 2 weeks to become established. Seedling length (cm) was used to determine growth. The following treatments were made: (1) normal water level, (2) water barely covering seedlings, (3) all water removed, but hydrosoil saturated, and (4) all water removed, hydrosoil unsaturated. Treatments were maintained for 4 weeks, after which water levels were adjusted to normal for all aquaria. All seedlings survived in aquaria with standing water. A mean survival rate of 53.3% was found in treatments where all water was removed but the hydrosoil remained saturated. Less than 10% of the seedlings survived when the hydrosoil was allowed to dry out. Under natural conditions, drying would likely be accompanied by temperature extremes that would make the treatment even more effective. Cabomba can be controlled by use of drawdown. However, seedlings located in areas where the hydrosoil remained saturated would have a good chance for survival. Therefore, water removal should be complete.

Hydrogen Ion Concentration

Seedlings were grown in Black Lake water in five aquaria at pH levels 4., 5.0, 6.0, 7.0, and 8.0. Two seedlings were planted in each of three small glass jars containing hydrosoil. Dilute HCl and 1.08 NNaOH were added dropwise to adjust lake water to the desired pH. The pH was checked colorimetrically and adjusted at 2-day intervals. Stem growth and branching were recorded. mean elongation values from each pH level were converted into percentage growth that seedlings at each level contributed to total observed growth. Arcsin Percentage Transformations were used to produce values suitable for testing. An LSD test (Least Significant Difference) was performed and treatment means were found to differ significantly at the 0.05 probability level.

The optimum pH level for growth of Cabomba seedlings is between pH 4.0 and 6.0. The ability to grow only under acidic conditions could help explain the geographical distribution of Cabomba. It is usually found in acidic waters or in waters where the substrate would produce acidic conditions. Liming of small bodies of water infested with Cabomba would probably produce a shift in succession to less aggressive species. The net effect would be to eliminate Cabomba as a problem species in these areas.

Turbidity

Into each of four 19 1 aquaria, 4 cm of hydrosoil were placed, and enough water was added to bring water levels to within 5 cm of the tops of aquaria. Two seedlings were planted in each of 12 glass jars filled with hydrosoil (six seedlings per aquarium). After 1 week, the bottom hydrosoil was manually agitated with a glass stirring rod twice daily for 43 days. Turbidity levels of (1) Control-3-10 Jackson Turbidity Units (JTU), (2) Low-30-45 JTU, (3) Moderate-70-110 JTU, and (4) High-300-2350 JTU were used in this study. Stem length and branching were measured after 9, 22, and 43 days. Results indicate that Cabomba can grow well in turbid water. Growth at moderate turbidity levels was greatest, followed by growth at the high turbidity level.

Growth and Reproduction

The range of Caboma caroliniana reaches from south central Texas north into Kansas, east to Michigan and upper New York, northern Massachusetts, and south to Florida. These studies indicate that Cabomba is capable of sexual reproduction in Louisiana. Nearly 100% germination was observed under greenhouse conditions. Factors believed to be of importance in Cabomba germination are red light, temperature, and high CO_2 levels. The seeds are found to have prolonged dormancy. Two-year-old or older seeds germinated under field conditions. Water level fluctuation effectively controlled Cabomba seedlings. Cabomba seedlings grow best at pH levels of 4.0 to 6.0 and are actually inhibited at pH levels 7.0 and 8.0.

Any stem section of Cabomba with a single pair of expanded leaves can produce a mature individual. The ability of Cabomba cuttings to grow under various pH levels appears to be similar to response to seedlings to different pH levels. It is found that nutrient uptake in Cabomba is primarily through leaves and stems.

Water Fluctuation

Use of water level fluctuation or drawdown in management of Louisiana lakes has been a very controversial issue. Opponents have cited temporary loss of recreational use of lakes for fishing, boating, and hunting purposes, in addition to economic loss as valid reasons for not employing drawdown as a management tool. Proponents, primarily aquatic plant biologists, have suggested that water level fluctuation is the only economically feasible method available for controlling submersed aquatic plants in the many public lakes of Louisiana. They have also pointed out that increased fish populations result when water fluctuation is utilized.

The water level of Black Lake was lowered 1.8 m beginning July 20, 1972, at a rate of approximately 10 cm/day. It was interrupted due to low dissolved oxygen concentrations that occurred in September 1972. An additional 0.6 m of water was removed beginning October 1, 1972, making a total drawdown of 2.4 m below normal pool stage, which was scheduled to be maintained until January 15, 1973. Abnormally heavy rainfall, beginning in November 1972 and extending through the spring months of 1973, produced a rapid rise in water level to a maximum of 2.1 m above normal pool stage in May 1973. This produced a total water fluctuation of 4.5 m within a 10-month period.

Transects were established at eight locations, ranging from the upper end to the lower end of the lake. Another sampling procedure involved vegetational analysis in 24 permanent 0.4 ha plots located at various depth intervals.

Vegetation samples were collected at 30.5 cm depth intervals along each transect, with the first sample being taken at 15 cm. Samples were collected using a 61 cm x 61 cm sheet metal quadrat equipped with cutting edges along the bottom. The unit was hoisted above water level by a boom attached to a 4.3 m, V-hull aluminum boat. A quick-release device allowed the sampling unit to free-fall, severing all vegetation in its path. A nylon net sack was placed over the quadrat top to retain vegetation. A cutter inserted in a slot near the quadrat bottom was used to sever stems at the hydrosoil surface. The unit was then raised above water and lowered into the boat, where all vegetation was removed and placed into a plastic bag. Plant samples collected each day were refrigerated until laboratory analysis. Plant samples were washed and sorted according to species, centrifuged at 1200 rpm for 2 min to remove excess water, and weighed.

The permanent plot study provided a means of testing reliability of the transect sampling method. Six permanent 0.4 ha plots were established in each of four depth zones: 0.1 to 1.8 m, 1.8 to 2.4 m, 2.4 to 3.1 m to 3.7 m. Plots were established 2 years prior to drawdown initiation and thus were not specifically designed to demonstrate any particular effect of drawdown on aquatic vegetation. Frequency of species found in plots were determined for the summers of 1971, 1972 (prior to drawdown), and 1973. Frequency was calculated by dividing the number of samples containing a species by the total number of samples. The bottom was checked for presence of vegetation using self-contained underwater breathing apparatus (SCUBA) prior to 1973 sampling, and no actual samples were taken in plots where no vegetation was observed.

Drawdown Effects

Many aquatic species cannot tolerate extreme fluctuations in water levels; thus, water-level adjustment can be an effective management technique. Fluctuation of water-levels is possible as a treatment in a water body where flows can be controlled, such as a reservoir; however, the multipurpose allocations (e.g., power generation, water supply, irrigation, recreation, navigation, etc.) of some of the larger reservoirs may not permit the variation of water level that is necessary to effect the desired level of treatment.

Cabomba, in Black Lake prior to drawdown, decreased 99.4% by August 1973. It is impossible to assess the effects of the 2.4 m drawdown independently of the high water levels experienced immediately following drawdown. However, other area lakes that experienced high levels similar to those of Black Lake (but which were not drawn down) were still heavily infested with a variety of aquatic plants in 1973.

Excellent control of Cabomba was achieved even at depths where water was not completely removed. This suggests that additional stress was placed on these plants that could not be attributed to drawdown alone. High water levels and cold temperatures during spring months could have been responsible for some of the additional stress placed upon these species. A plankton bloom during late May and early June 1973 could also have placed additional stress on these species.

SUMMARY AND CONCLUSIONS

Water removal (drawdown) produced a decrease in values for temperature, dissolved oxygen, and pH. Effects of drawdown on other physicochemical factors were non-existent or negligible. Periods of high inflow produced increased in values of ammonia, nitrates, apparent color, orthophosphates, and turbidity, while specific conductance decreased with period of high inflow. Other characteristics were unaffected by inflow rates or effects were inconclusive as to whether directly related to high inflow. Generally, no changes in water quality that would produce drastic changes in population levels of desirable aquatic organisms were observed.

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